The Role of Ubiquitous Computing in Facility Life Cycle Information Integration

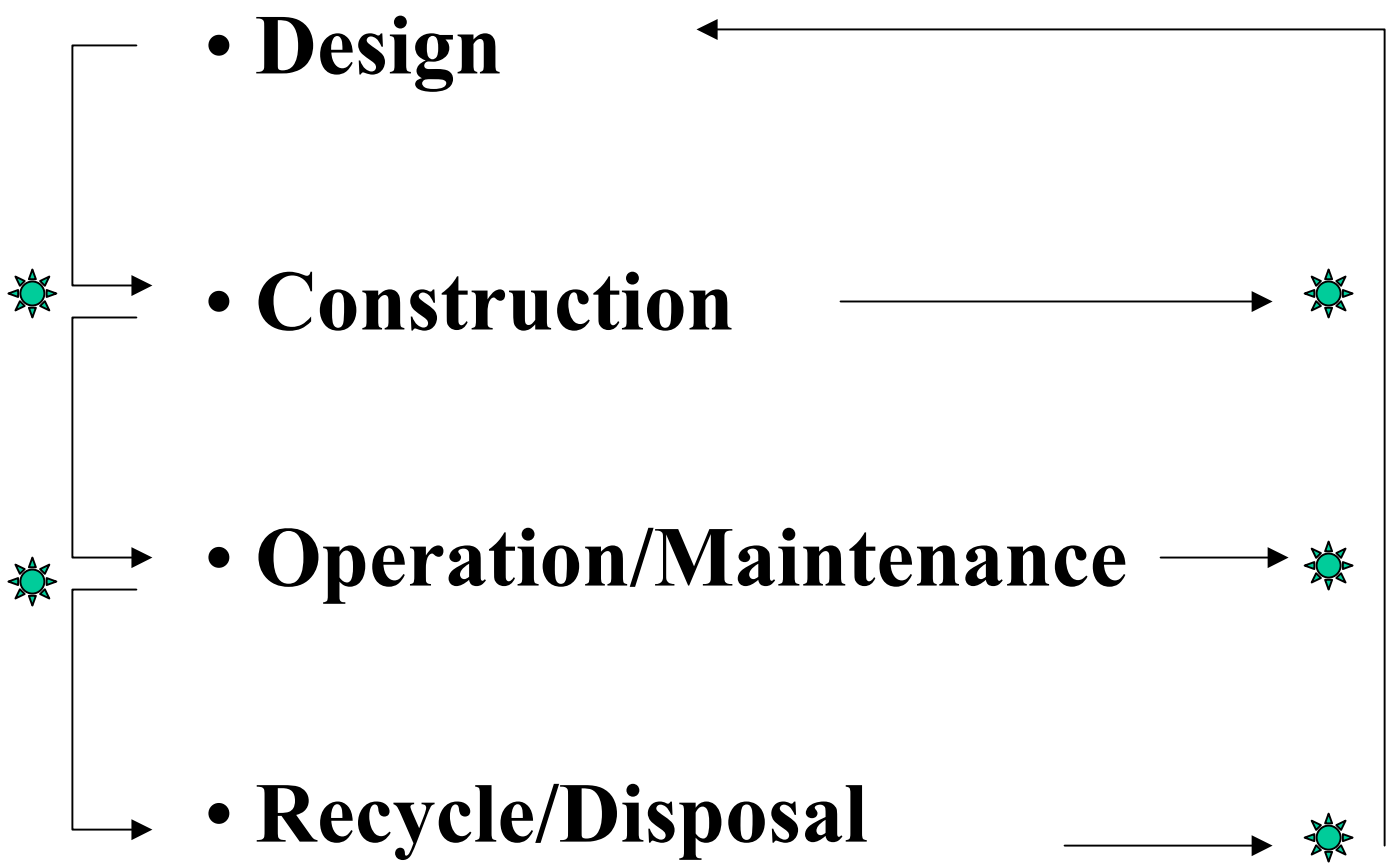
April 26 & 27, 2004

at USACERL

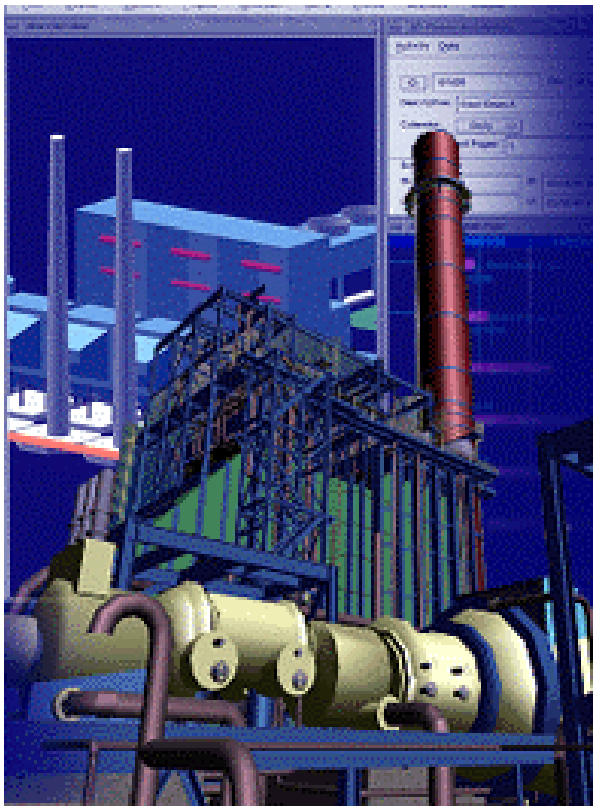
by

Liang Y. Liu, Associate Professor
Construction Engineering & Management Program
Department of Civil & Environmental Engineering
University of Illinois at Urbana-Champaign

Gaps in Facility Life-cycle Information Management



Challenges of Facility Operators/Maintainers



- Lack of accurate as-built
- Condition checking
- Record keeping
- Resource management
- Field data collection
- Data/information/knowledge integration

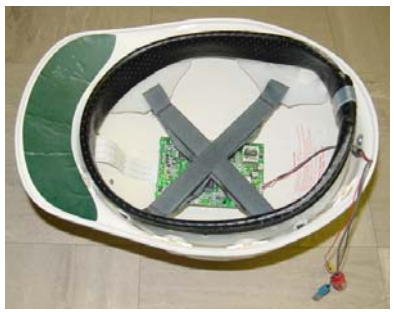
Promising IT Advances

- **Mobile Computing**
- **Wireless Communications**
- **Sensors**

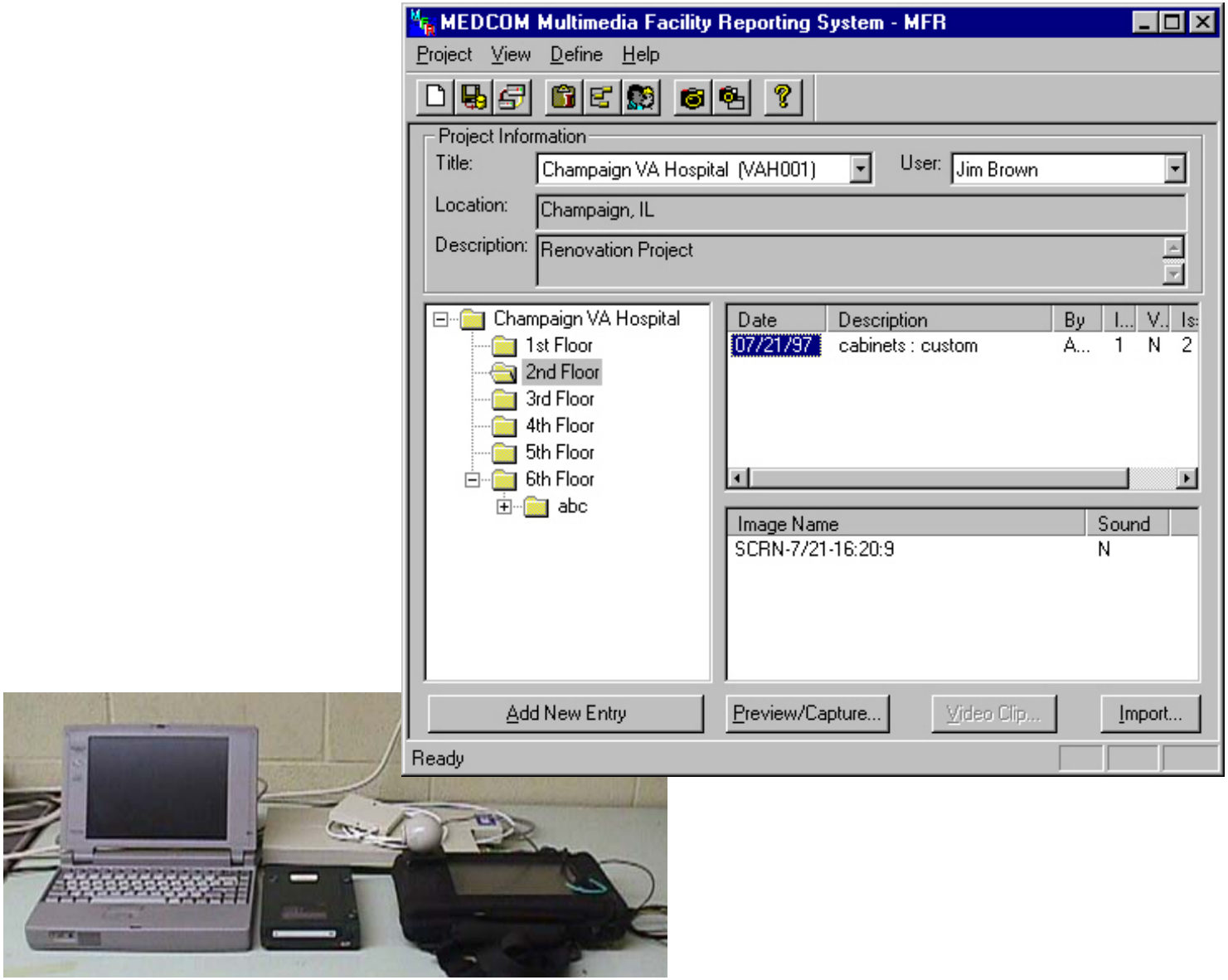
Ubiquitous Computing

Case Studies & Field Tests

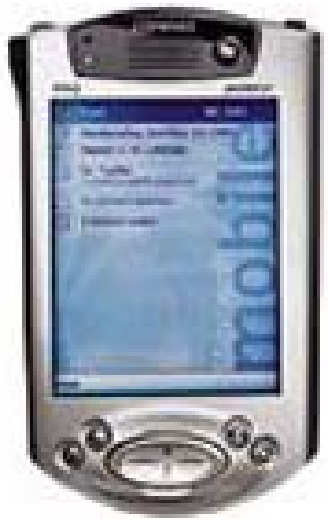
1. **Digital Hardhat System**
2. **Tunnel Log System**
3. **BLRA Inspection System**
4. **Sensor Monitoring**



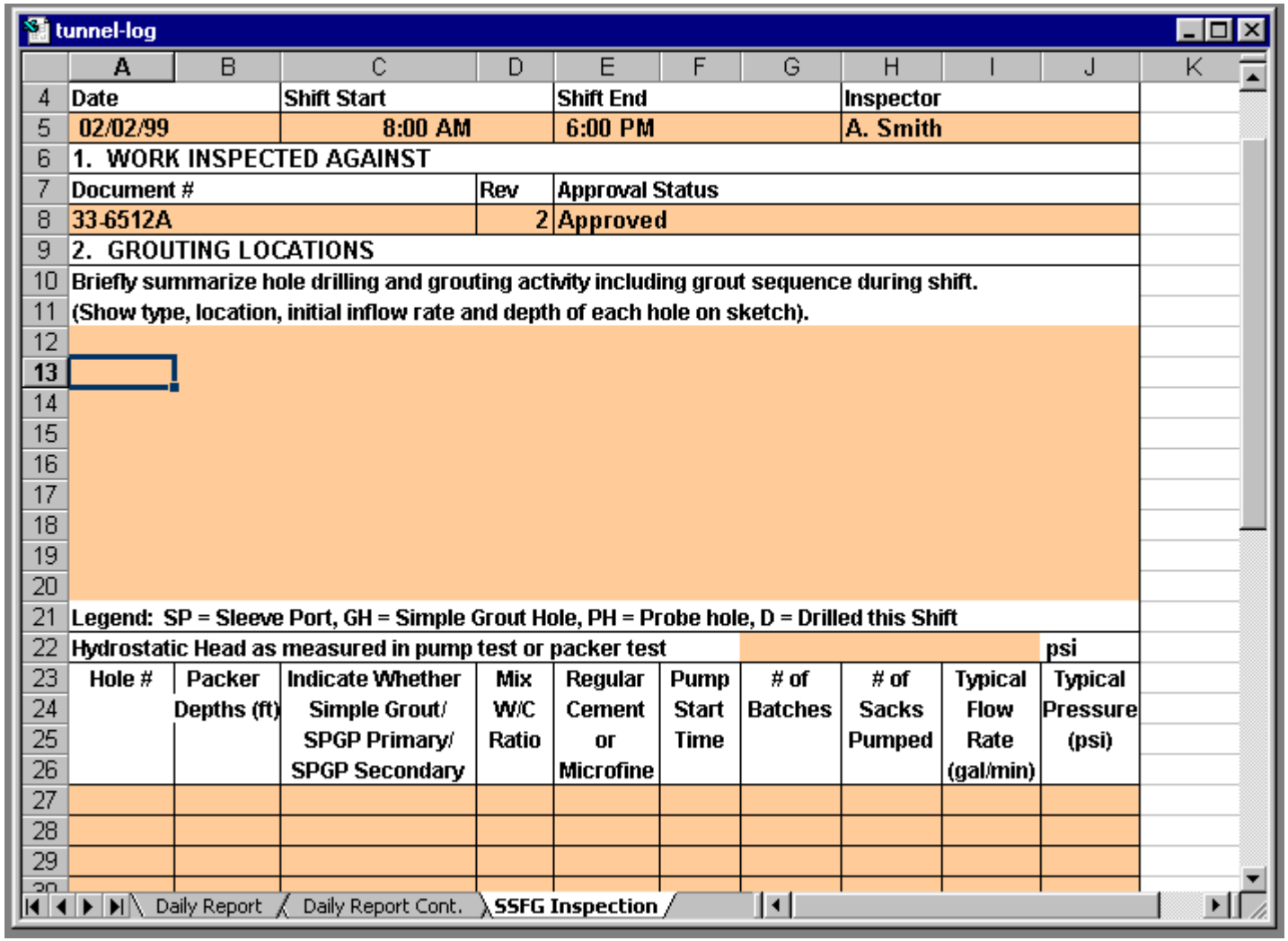
Wearable Computer
UIUC Research Prototype


MEDCOM Multimedia Facility Reporting System - MFR
Project View Define Help
Project Information
Title: Champaign VA Hospital (VAH001)
User: Jim Brown
Location: Champaign, IL
Description: Renovation Project
Champaign VA Hospital
1st Floor
2nd Floor
3rd Floor
4th Floor
5th Floor
6th Floor
abc
Date Description By I... V.. Is:
07/21/97 cabinets : custom A... 1 N 2
Image Name Sound
SCRN-7/21-16:20:9 N
Add New Entry
Preview/Capture...
Video Clip...
Import...
Ready

Pocket PC, Palm Pilot, Tablet PC, and Wearable Computers



Tunnel Log System



tunnel-log

	Date	Shift Start	Shift End	Inspector
5	02/02/99	8:00 AM	6:00 PM	A. Smith

1. WORK INSPECTED AGAINST

Document #	Rev	Approval Status
33-6512A	2	Approved

2. GROUTING LOCATIONS

Briefly summarize hole drilling and grouting activity including grout sequence during shift.
(Show type, location, initial inflow rate and depth of each hole on sketch).

Legend: SP = Sleeve Port, GH = Simple Grout Hole, PH = Probe hole, D = Drilled this Shift

Hydrostatic Head as measured in pump test or packer test psi

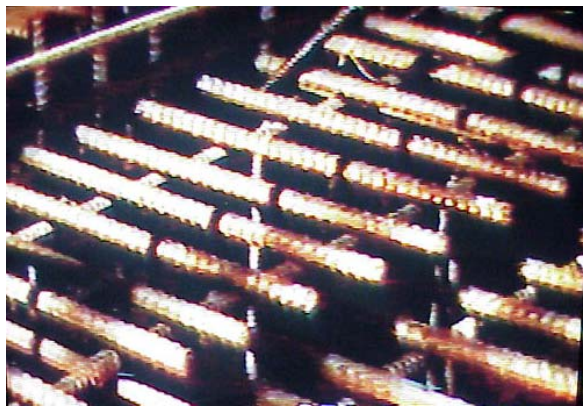
Hole #	Packer Depths (ft)	Indicate Whether Simple Grout/ SPGP Primary/ SPGP Secondary	Mix W/C Ratio	Regular Cement or Microfine	Pump Start Time	# of Batches	# of Sacks Pumped	Typical Flow Rate (gal/min)	Typical Pressure (psi)

Daily Report | Daily Report Cont. | SSFG Inspection

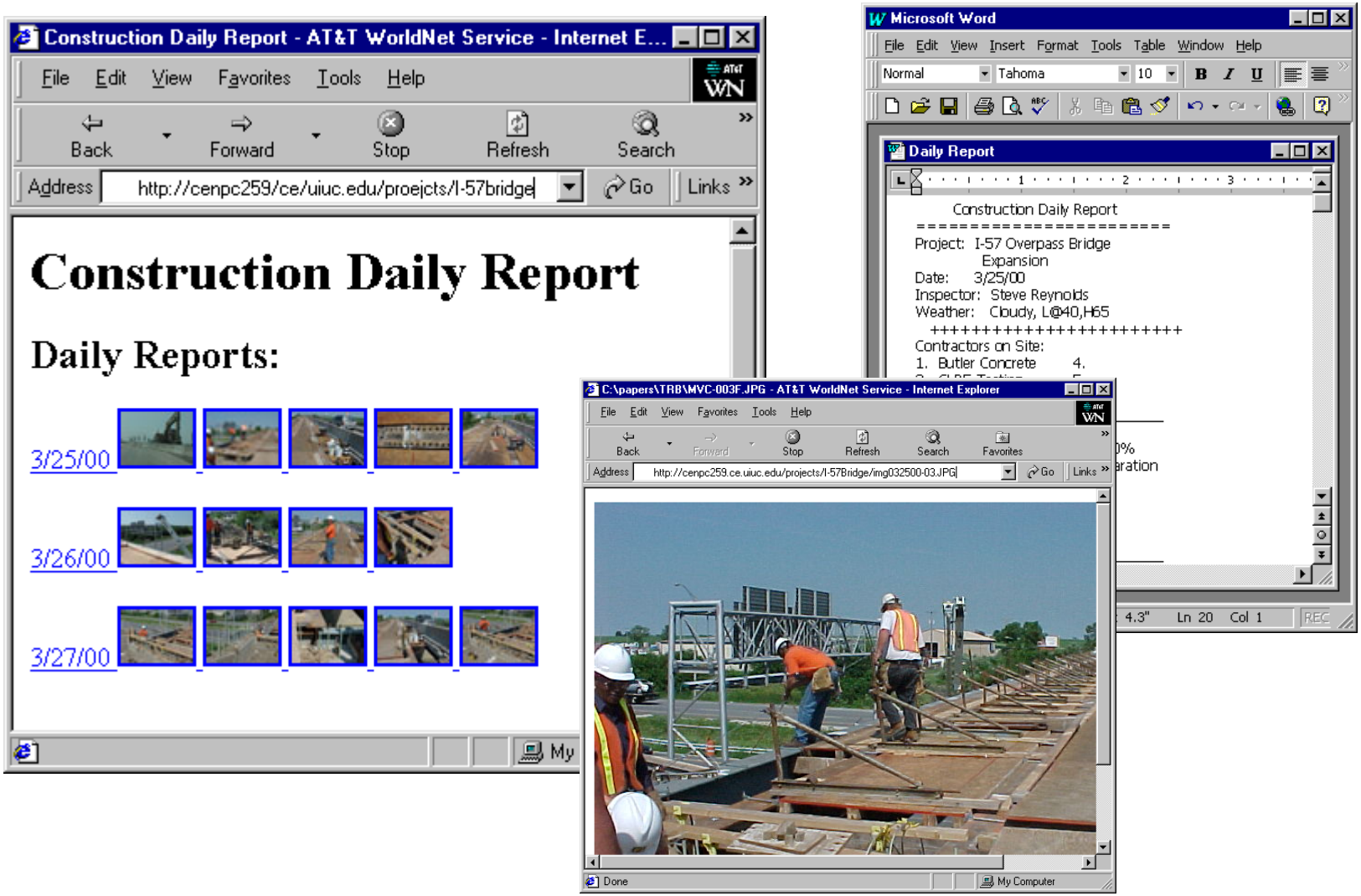
Site Images of Tunnel Construction








Multimedia Documentation & Internet-based Access/Storage



Web-based Inspection & Administration System

Case Study:

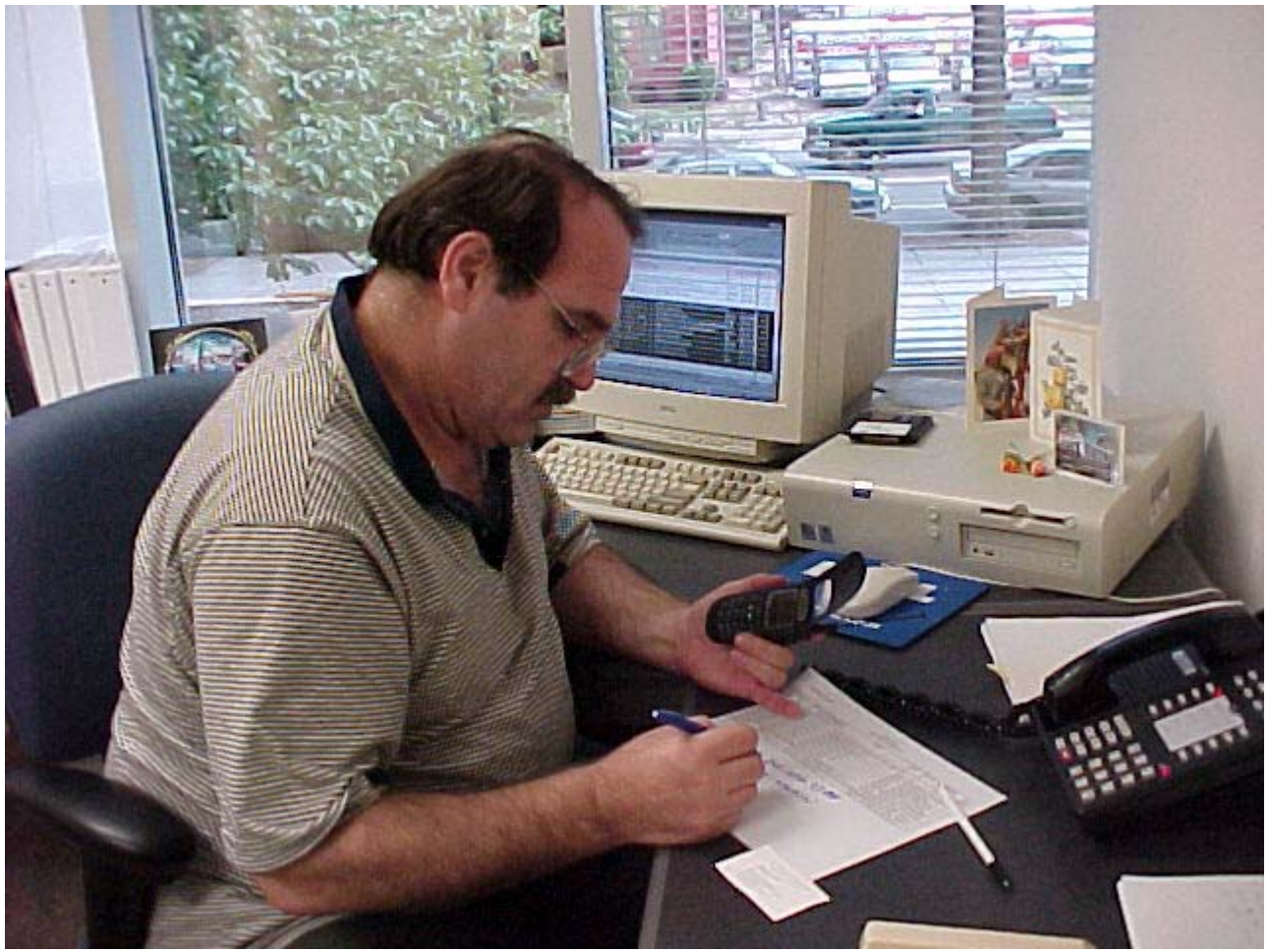
DC Government Building & Land Regulatory Administration

1. End User Study
2. Process Analysis
3. Technological Analysis
4. Implementation Example

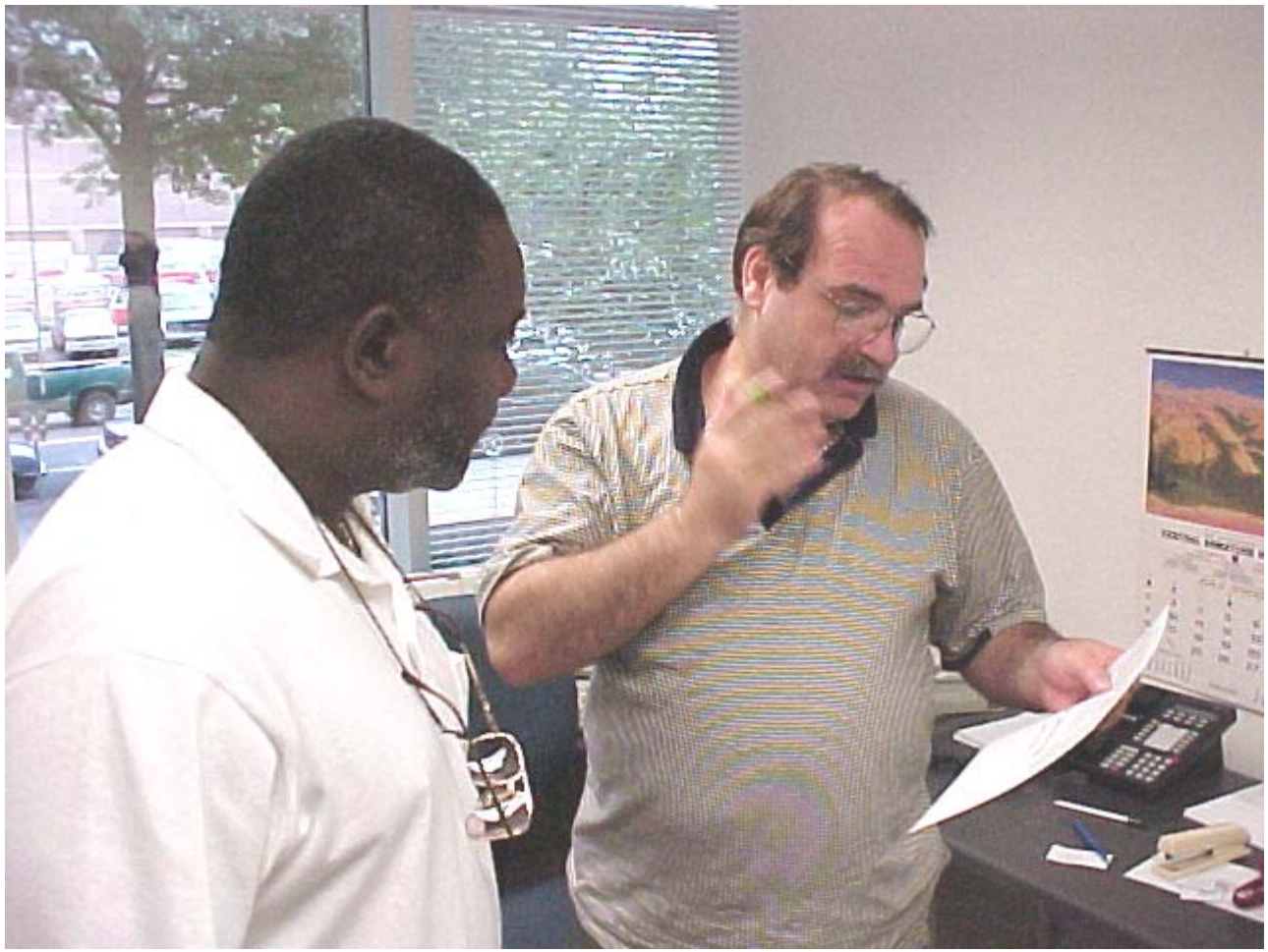
DCRA-BLRA Head Quarter

(Inspectors arrive for work +-7:30am)

Inspection Planning and Scheduling



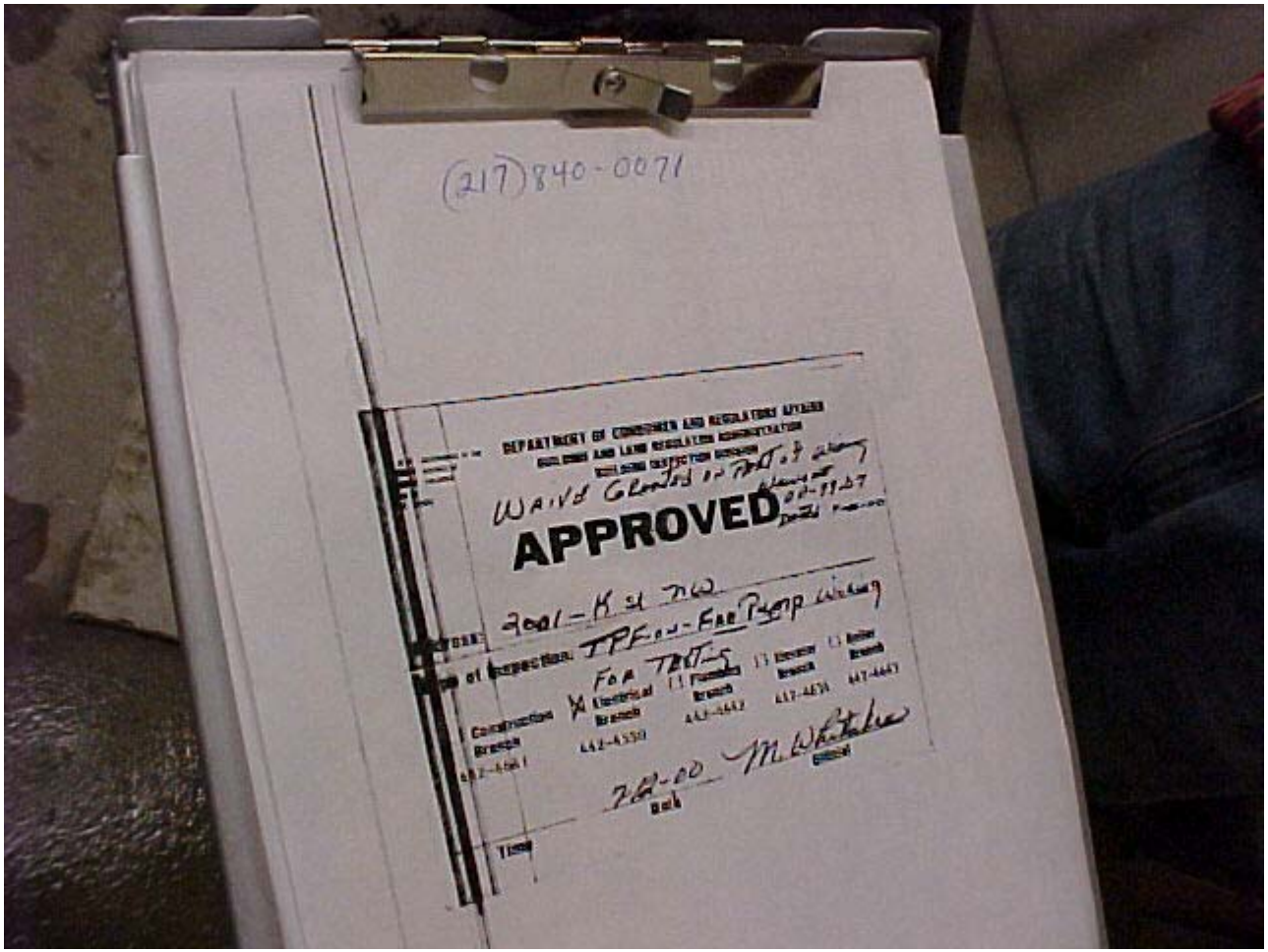
Inspector/Coordinator Consultation



Inspectors locate permit information

(On-line computerized system is being deployed)

Inspector's Notepad

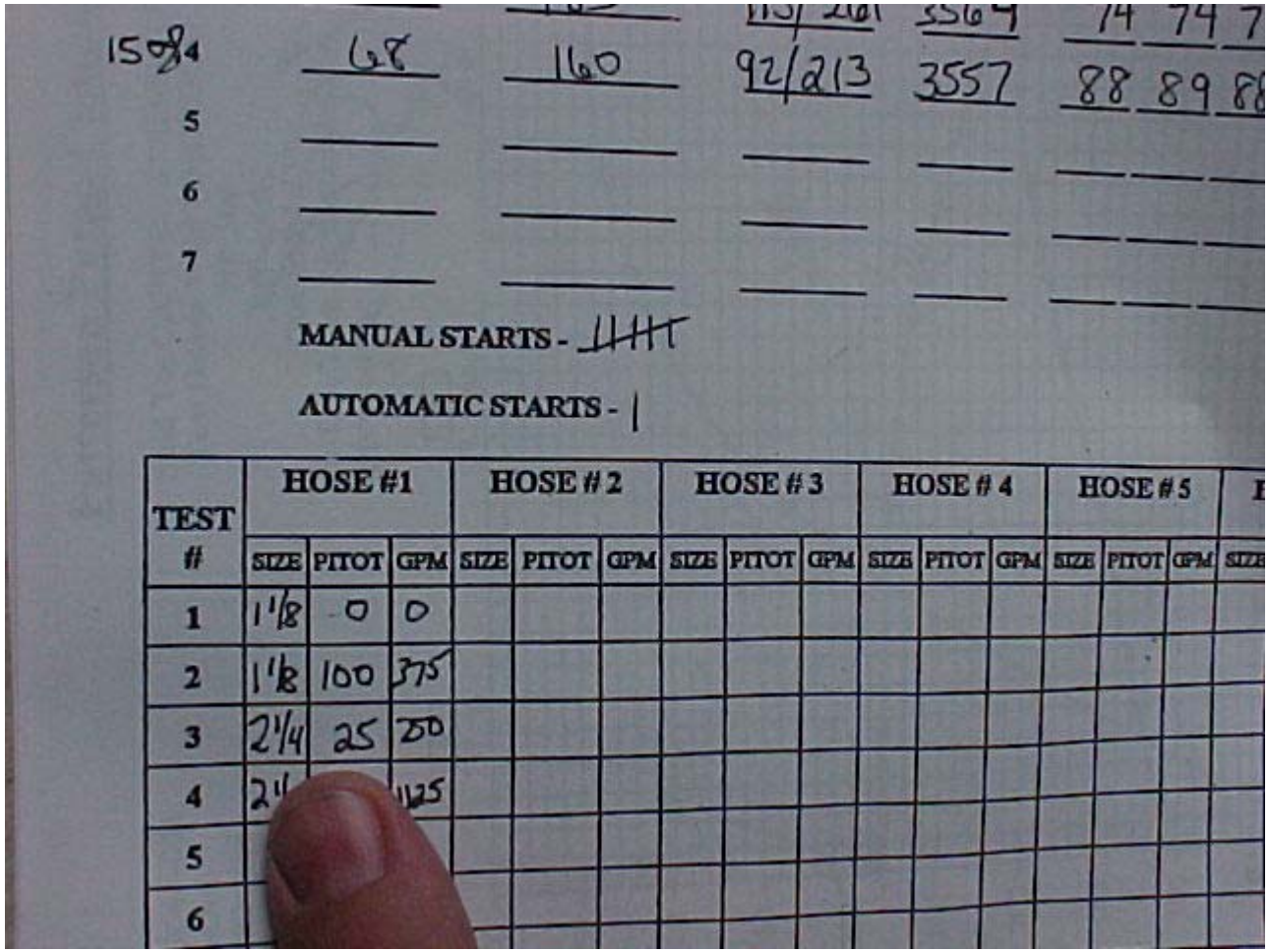


Typical site condition for inspection:

Indoor, outdoor, construction equipment, materials, personnel, & temporary facilities

Inspectors communicate/coordinate with other inspectors & BLRA office from the site

On-site Test Results Recording



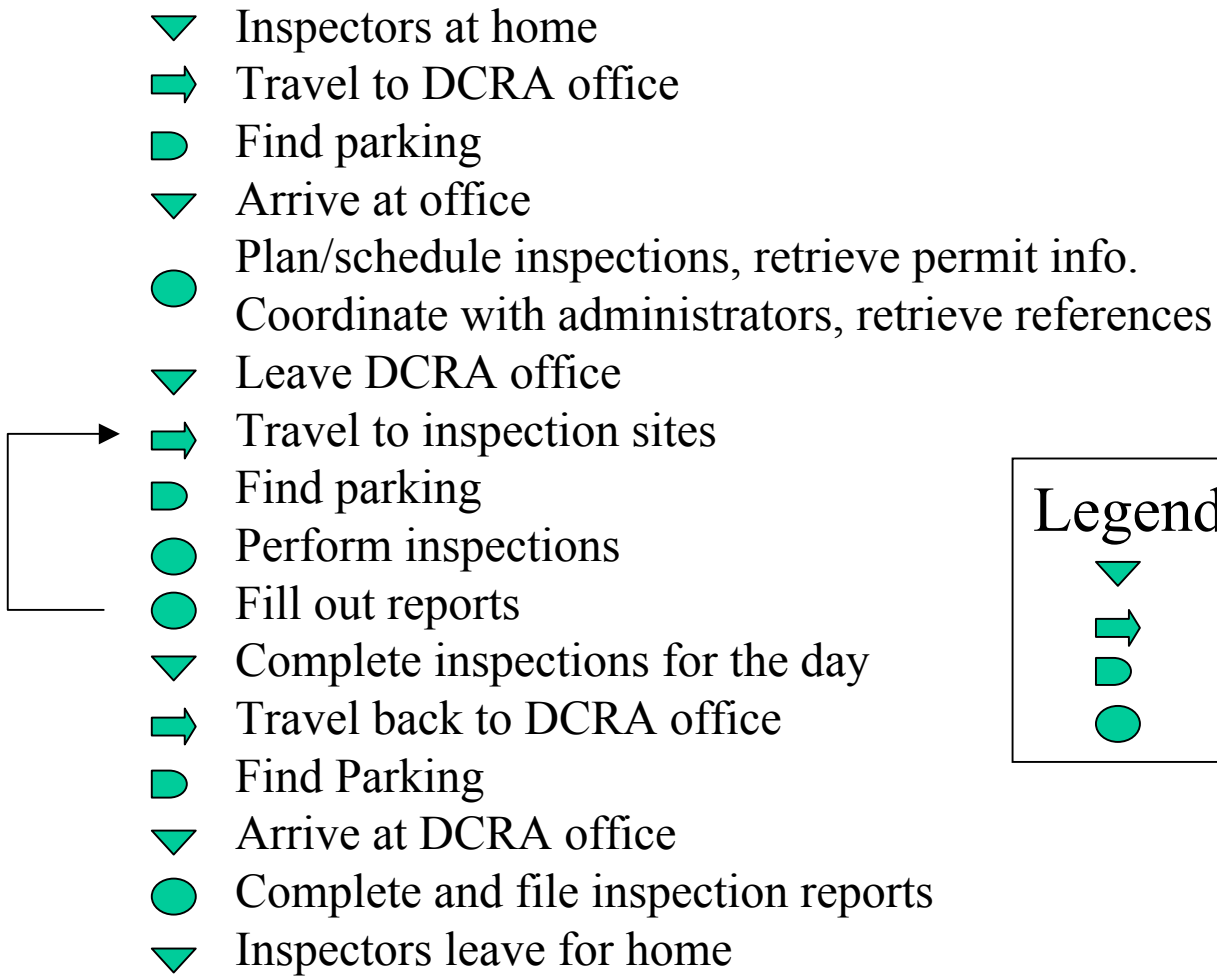
15	4	68	160	92/213	3557	88 89 88
	5					
	6					
	7					

MANUAL STARTS - ||||

AUTOMATIC STARTS - |

TEST #	HOSE #1			HOSE # 2			HOSE # 3			HOSE # 4			HOSE # 5			
	SIZE	PITOT	GPM	SIZE	PITOT	GPM	SIZE	PITOT	GPM	SIZE	PITOT	GPM	SIZE	PITOT	GPM	SIZE
1	1 1/8	0	0													
2	1 1/8	100	375													
3	2 1/4	25	250													
4	2 1/4		1125													
5																
6																

Inspector Tasks Analysis



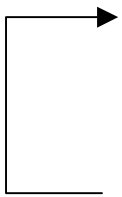
Where Information Technology Could Be Useful?

Information Technology (IT):
Computer hardware, software & telecommunications technologies
that allows us to access information without the barriers of time and distance.

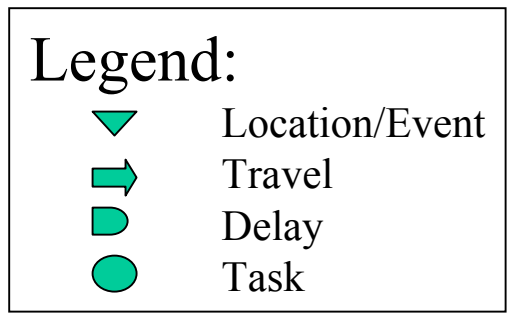
Promising areas for DCRA-BLRA inspections:

- Inspection scheduling (by inspectors or by administrators)
- Reporting writing and filing
- Permit information on-line and on sites
- Computerized reference access to BOCA codes & others
- Multimedia information capture (text, images, and sound)
- Wireless data synchronization/communications
- IT-based teams

Proposed Inspector Tasks Using Information Technology



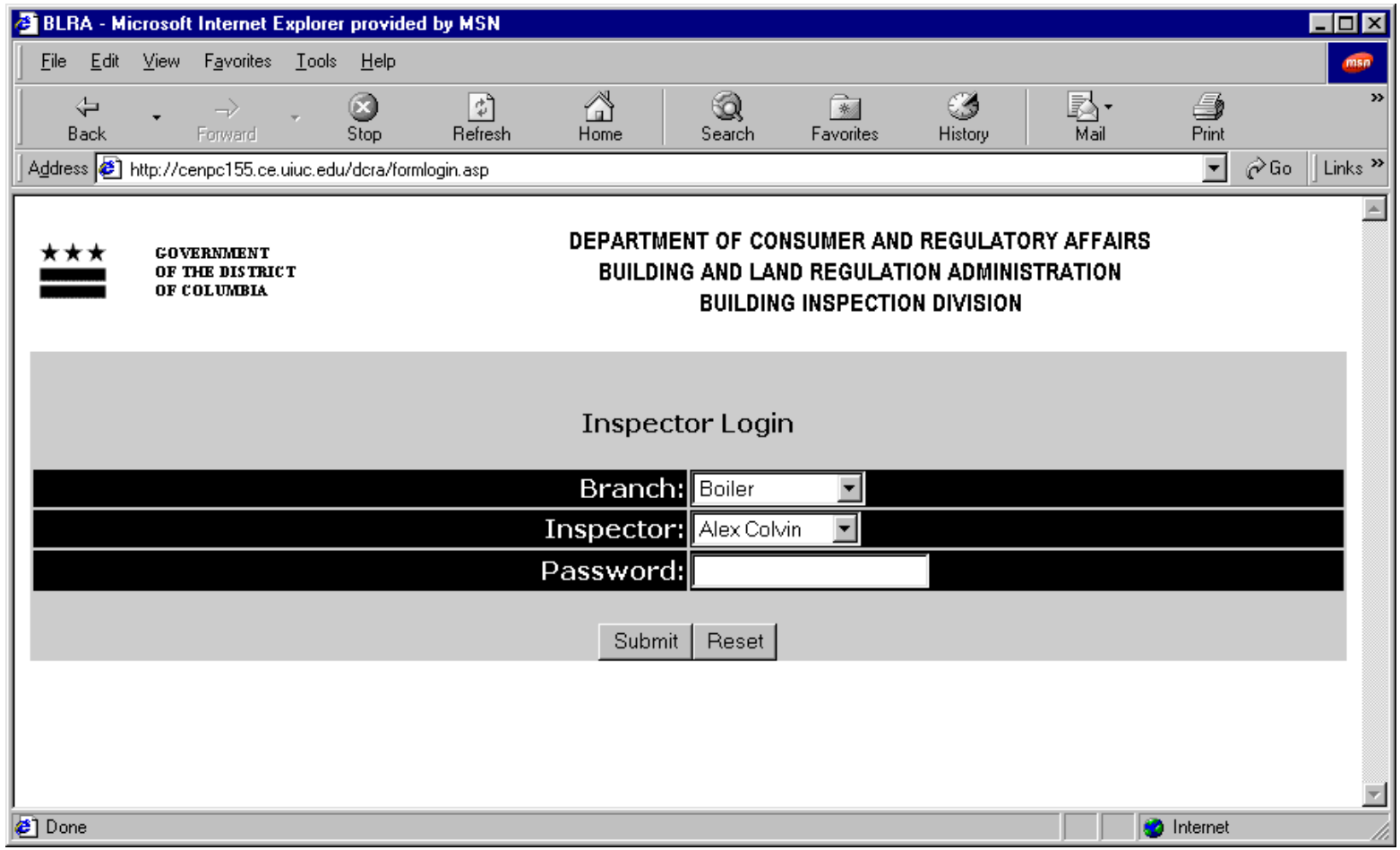
- Inspectors at home
- Inspectors turn on computer, log in to start work day
- View inspection schedule from the computer
- Travel to inspection sites
- Find parking
- Perform inspections
- Fill out reports directly on hand-held computer, automatic synchronization with DCRA computer
- Complete inspections for the day
- Inspectors leave for home

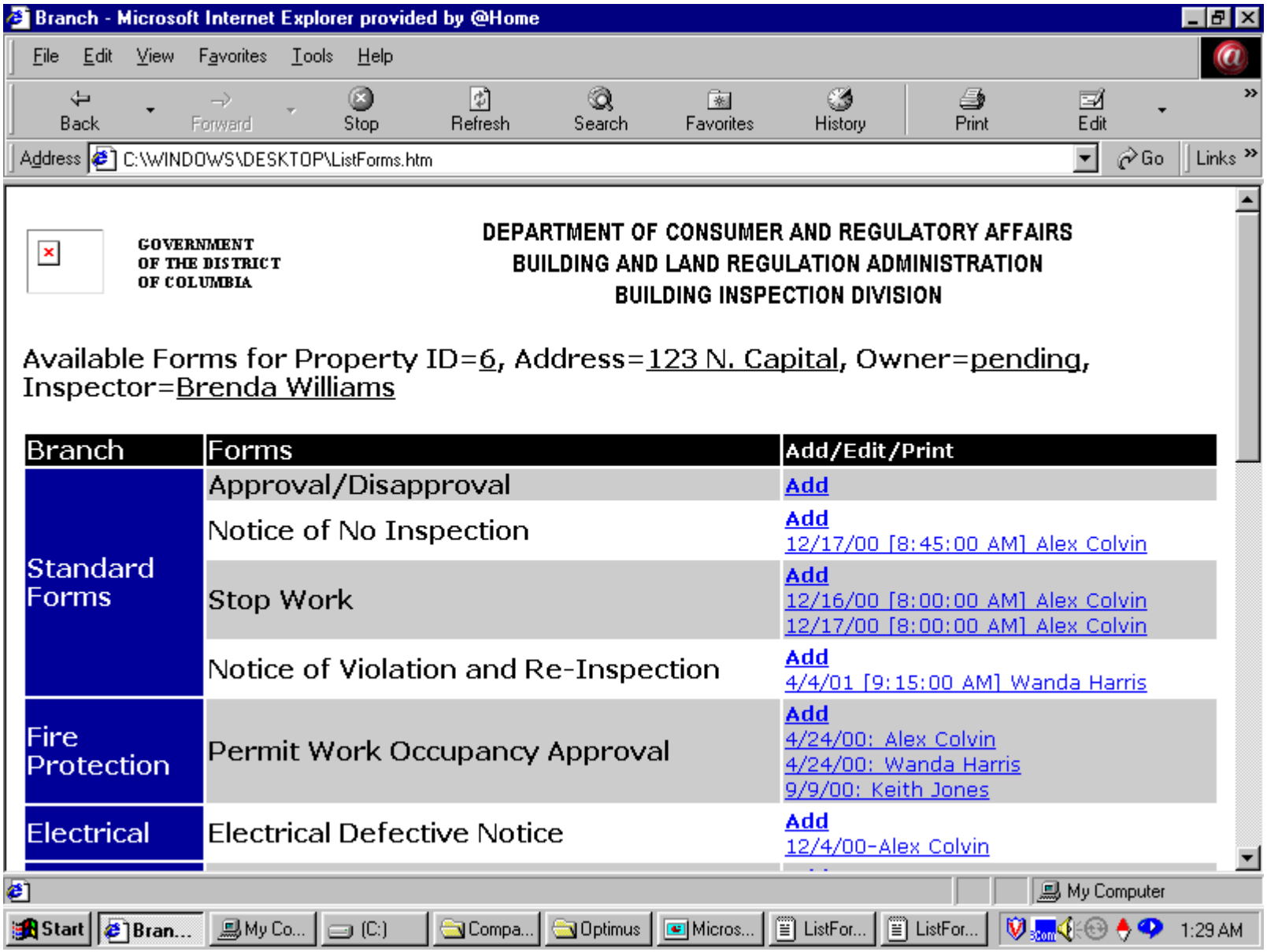


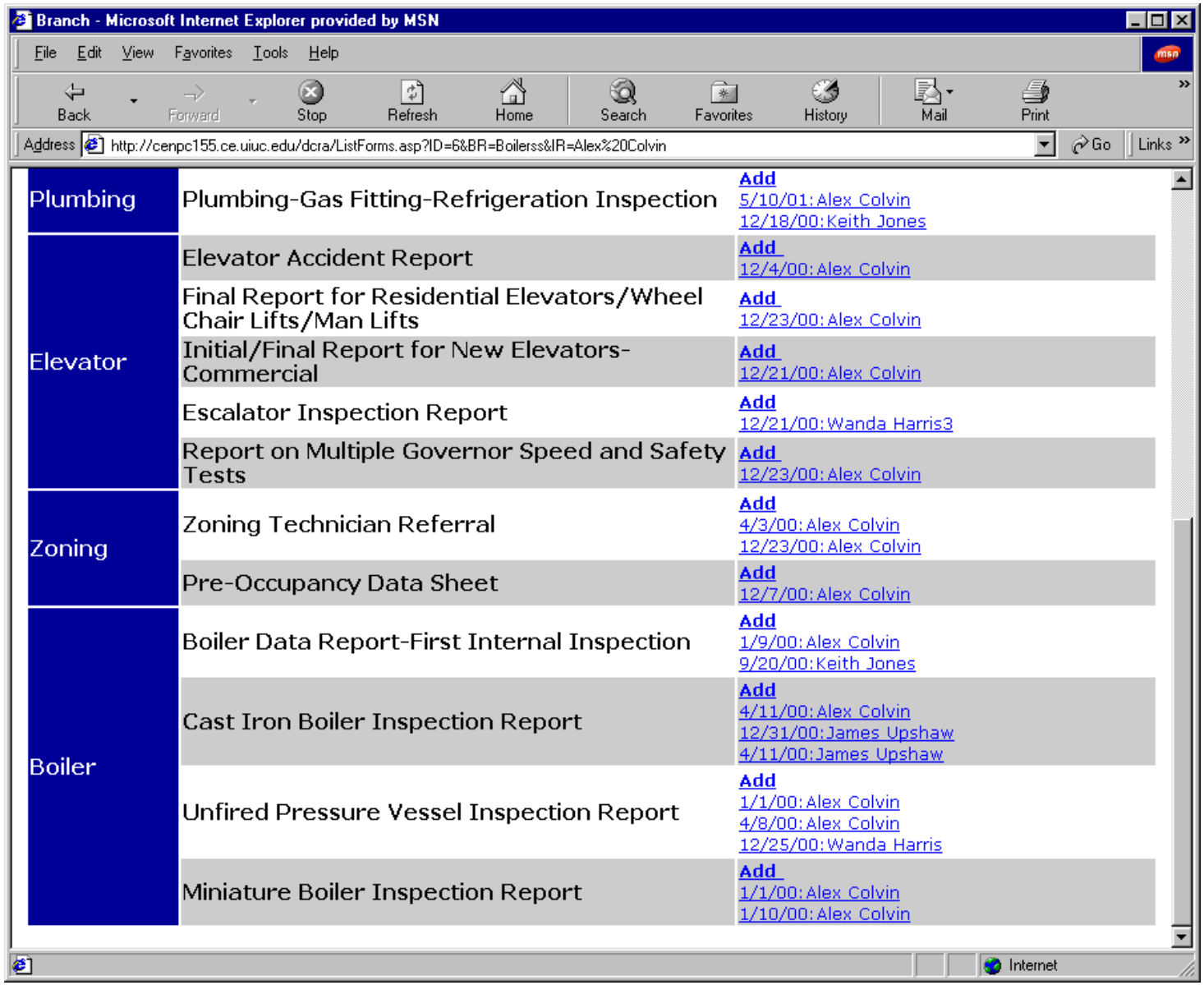
Technology Assessment

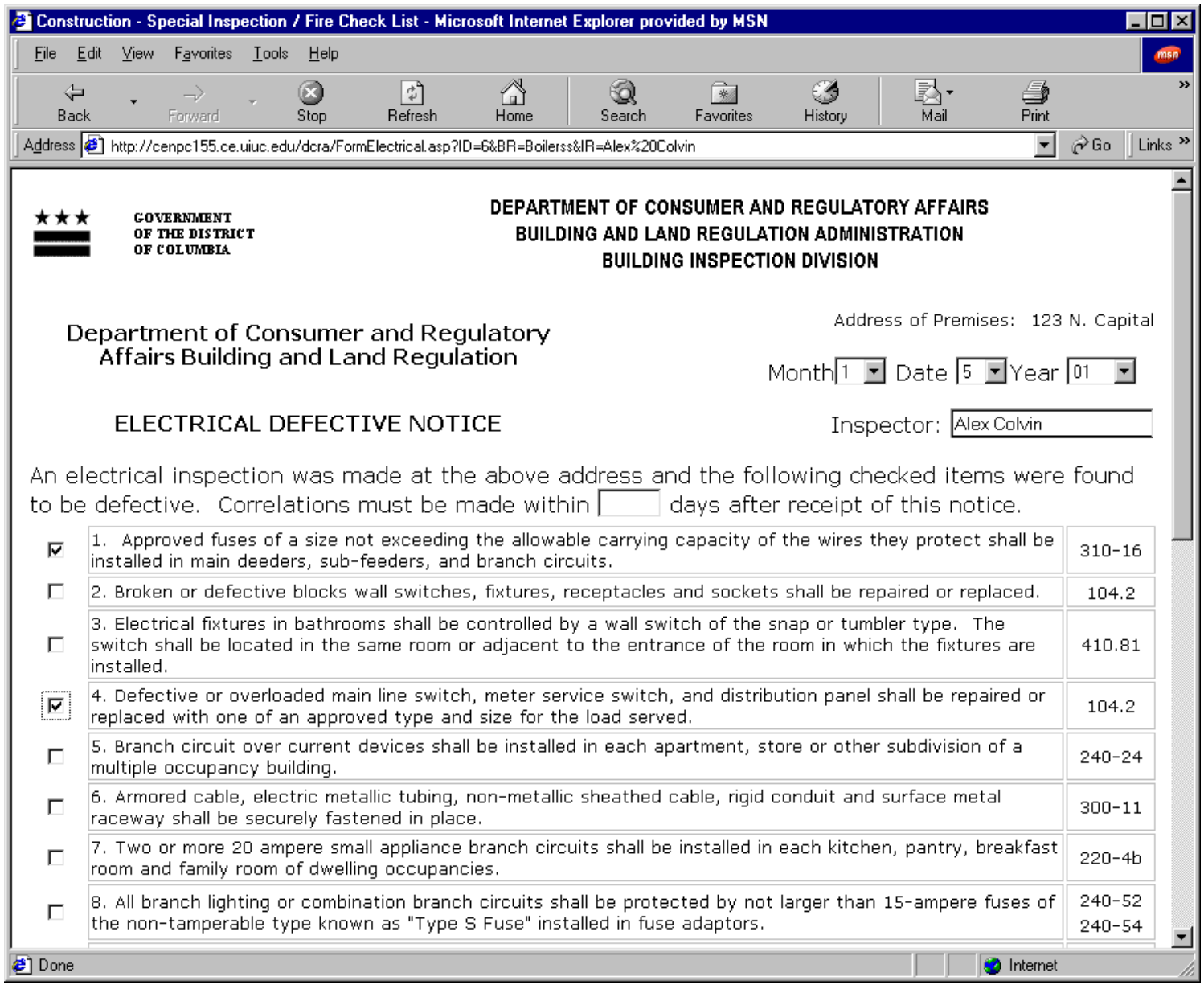
Four Possible Platforms:

1. **Lightweight notebook computer**
2. **Wearable Computer**
3. **Palm/Pocket PC's**
4. **Web/Internet Enabled Cellular Phones**


BLRA - Microsoft Internet Explorer provided by MSN
File Edit View Favorites Tools Help
Back Forward Stop Refresh Home Search Favorites History Mail Print
Address http://cenpc155.ce.uiuc.edu/dcra/formlogin.asp
Go Links
GOVERNMENT
OF THE DISTRICT
OF COLUMBIA
DEPARTMENT OF CONSUMER AND REGULATORY AFFAIRS
BUILDING AND LAND REGULATION ADMINISTRATION
BUILDING INSPECTION DIVISION
Inspector Login
Branch: Boiler
Inspector: Alex Colvin
Password:
Submit Reset
Done
Internet


Branch - Microsoft Internet Explorer provided by @Home
File Edit View Favorites Tools Help
Back Forward Stop Refresh Search Favorites History Print Edit
Address C:\WINDOWS\DESKTOP\ListForms.htm
Go Links
GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF CONSUMER AND REGULATORY AFFAIRS
BUILDING AND LAND REGULATION ADMINISTRATION
BUILDING INSPECTION DIVISION
Available Forms for Property ID=6, Address=123 N. Capital, Owner=pending, Inspector=Brenda Williams
Branch
Forms
Add/Edit/Print
Standard Forms
Approval/Disapproval
Add
Notice of No Inspection
Add
12/17/00 [8:45:00 AM] Alex Colvin
Stop Work
Add
12/16/00 [8:00:00 AM] Alex Colvin
12/17/00 [8:00:00 AM] Alex Colvin
Notice of Violation and Re-Inspection
Add
4/4/01 [9:15:00 AM] Wanda Harris
Fire Protection
Permit Work Occupancy Approval
Add
4/24/00: Alex Colvin
4/24/00: Wanda Harris
9/9/00: Keith Jones
Electrical
Electrical Defective Notice
Add
12/4/00-Alex Colvin
My Computer
Start
Bran...
My Co...
(C:)
Compa...
Optimus
Micros...
ListFor...
ListFor...
1:29 AM


Branch - Microsoft Internet Explorer provided by MSN
File Edit View Favorites Tools Help
Back Forward Stop Refresh Home Search Favorites History Mail Print
Address http://cenpc155.ce.uiuc.edu/dcra/ListForms.asp?ID=6&BR=Boilerss&IR=Alex%20Colvin
Go Links
Plumbing
Plumbing-Gas Fitting-Refrigeration Inspection
Add
5/10/01:Alex Colvin
12/18/00:Keith Jones
Elevator
Elevator Accident Report
Add
12/4/00:Alex Colvin
Final Report for Residential Elevators/Wheel Chair Lifts/Man Lifts
Add
12/23/00:Alex Colvin
Initial/Final Report for New Elevators-Commercial
Add
12/21/00:Alex Colvin
Escalator Inspection Report
Add
12/21/00:Wanda Harris3
Report on Multiple Governor Speed and Safety Tests
Add
12/23/00:Alex Colvin
Zoning
Zoning Technician Referral
Add
4/3/00:Alex Colvin
12/23/00:Alex Colvin
Pre-Occupancy Data Sheet
Add
12/7/00:Alex Colvin
Boiler
Boiler Data Report-First Internal Inspection
Add
1/9/00:Alex Colvin
9/20/00:Keith Jones
Cast Iron Boiler Inspection Report
Add
4/11/00:Alex Colvin
12/31/00:James Upshaw
4/11/00:James Upshaw
Unfired Pressure Vessel Inspection Report
Add
1/1/00:Alex Colvin
4/8/00:Alex Colvin
12/25/00:Wanda Harris
Miniature Boiler Inspection Report
Add
1/1/00:Alex Colvin
1/10/00:Alex Colvin
Internet


Construction - Special Inspection / Fire Check List - Microsoft Internet Explorer provided by MSN
File Edit View Favorites Tools Help
Back Forward Stop Refresh Home Search Favorites History Mail Print
Address http://cenpc155.ce.uiuc.edu/dcra/FormElectrical.asp?ID=6&BR=Boilerss&IR=Alex%20Colvin
Go Links
GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF CONSUMER AND REGULATORY AFFAIRS
BUILDING AND LAND REGULATION ADMINISTRATION
BUILDING INSPECTION DIVISION
Department of Consumer and Regulatory Affairs Building and Land Regulation
Address of Premises: 123 N. Capital
Month 1 Date 5 Year 01
ELECTRICAL DEFECTIVE NOTICE
Inspector: Alex Colvin
An electrical inspection was made at the above address and the following checked items were found to be defective. Correlations must be made within days after receipt of this notice.
1. Approved fuses of a size not exceeding the allowable carrying capacity of the wires they protect shall be installed in main deeders, sub-feeders, and branch circuits. 310-16
2. Broken or defective blocks wall switches, fixtures, receptacles and sockets shall be repaired or replaced. 104.2
3. Electrical fixtures in bathrooms shall be controlled by a wall switch of the snap or tumbler type. The switch shall be located in the same room or adjacent to the entrance of the room in which the fixtures are installed. 410.81
4. Defective or overloaded main line switch, meter service switch, and distribution panel shall be repaired or replaced with one of an approved type and size for the load served. 104.2
5. Branch circuit over current devices shall be installed in each apartment, store or other subdivision of a multiple occupancy building. 240-24
6. Armored cable, electric metallic tubing, non-metallic sheathed cable, rigid conduit and surface metal raceway shall be securely fastened in place. 300-11
7. Two or more 20 ampere small appliance branch circuits shall be installed in each kitchen, pantry, breakfast room and family room of dwelling occupancies. 220-4b
8. All branch lighting or combination branch circuits shall be protected by not larger than 15-ampere fuses of the non-tamperable type known as "Type S Fuse" installed in fuse adaptors. 240-52 240-54
Done
Internet

New Generation of Sensors and Wireless Technologies

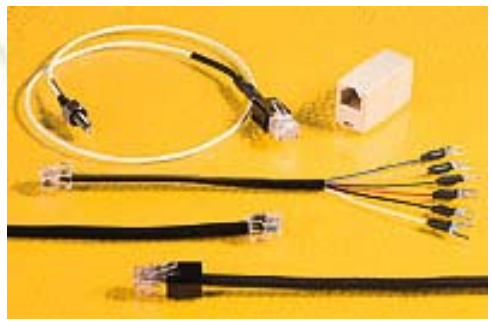
Tri-axial accelerometer

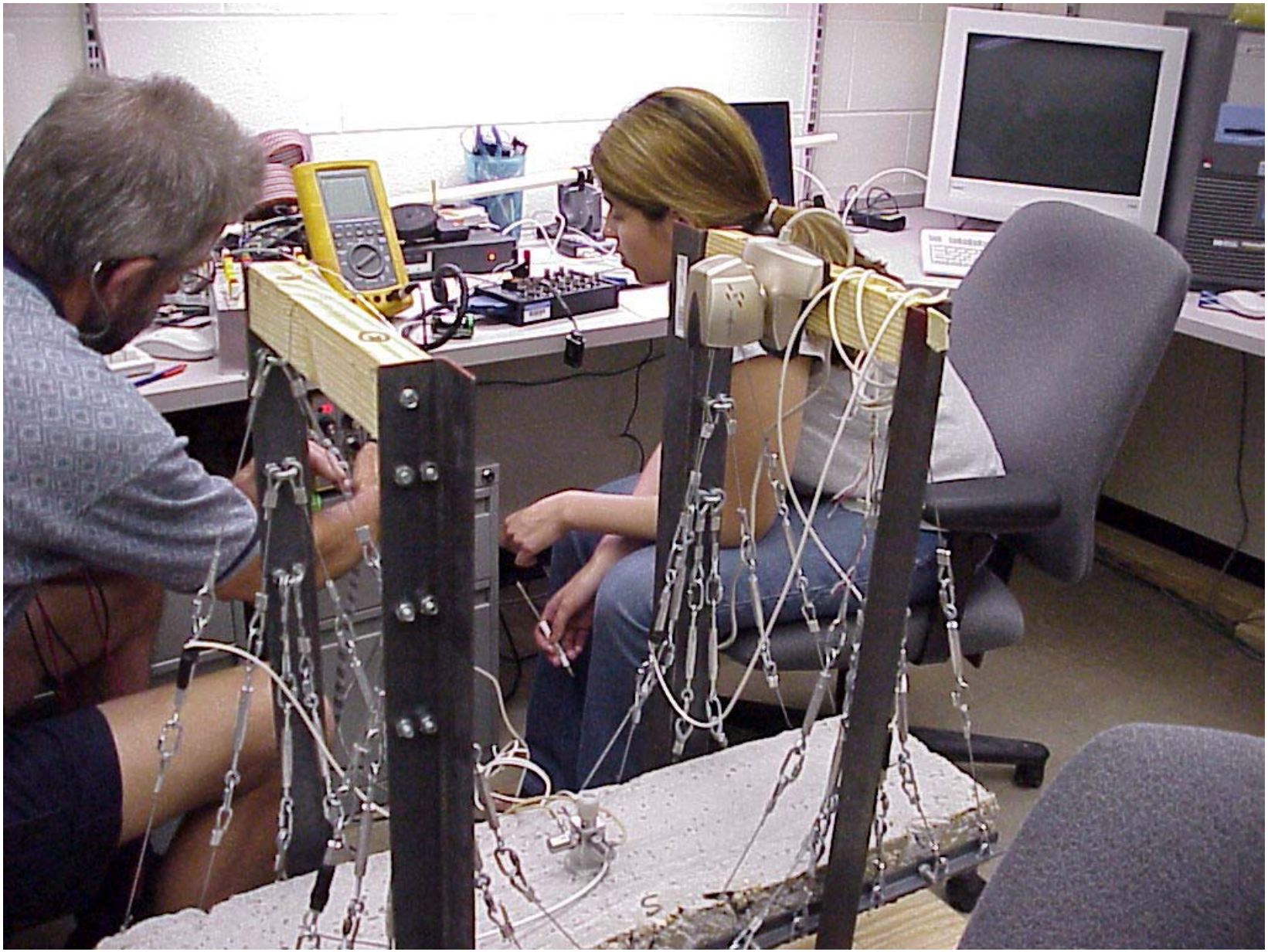
Strain gauges

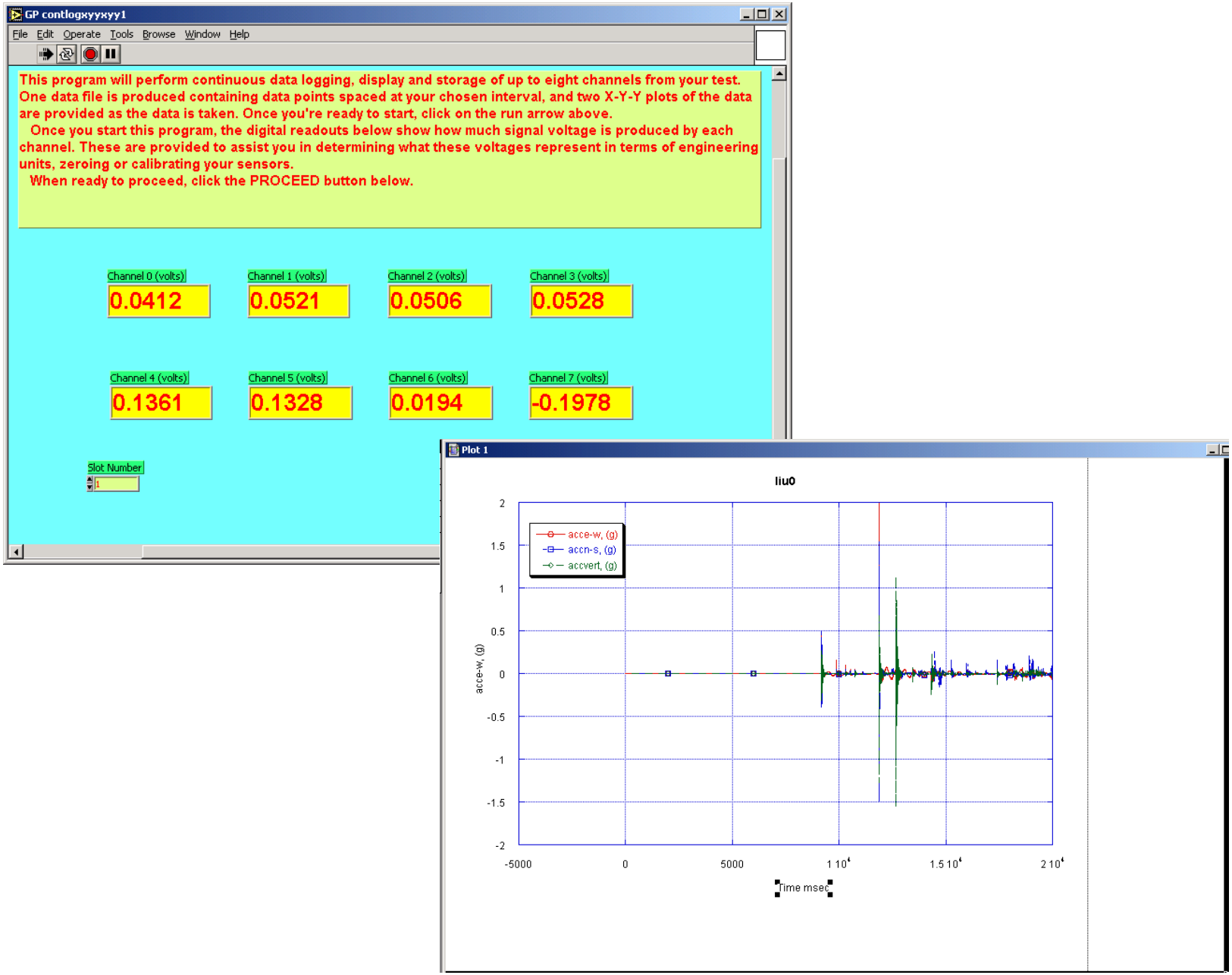
Inclinometer

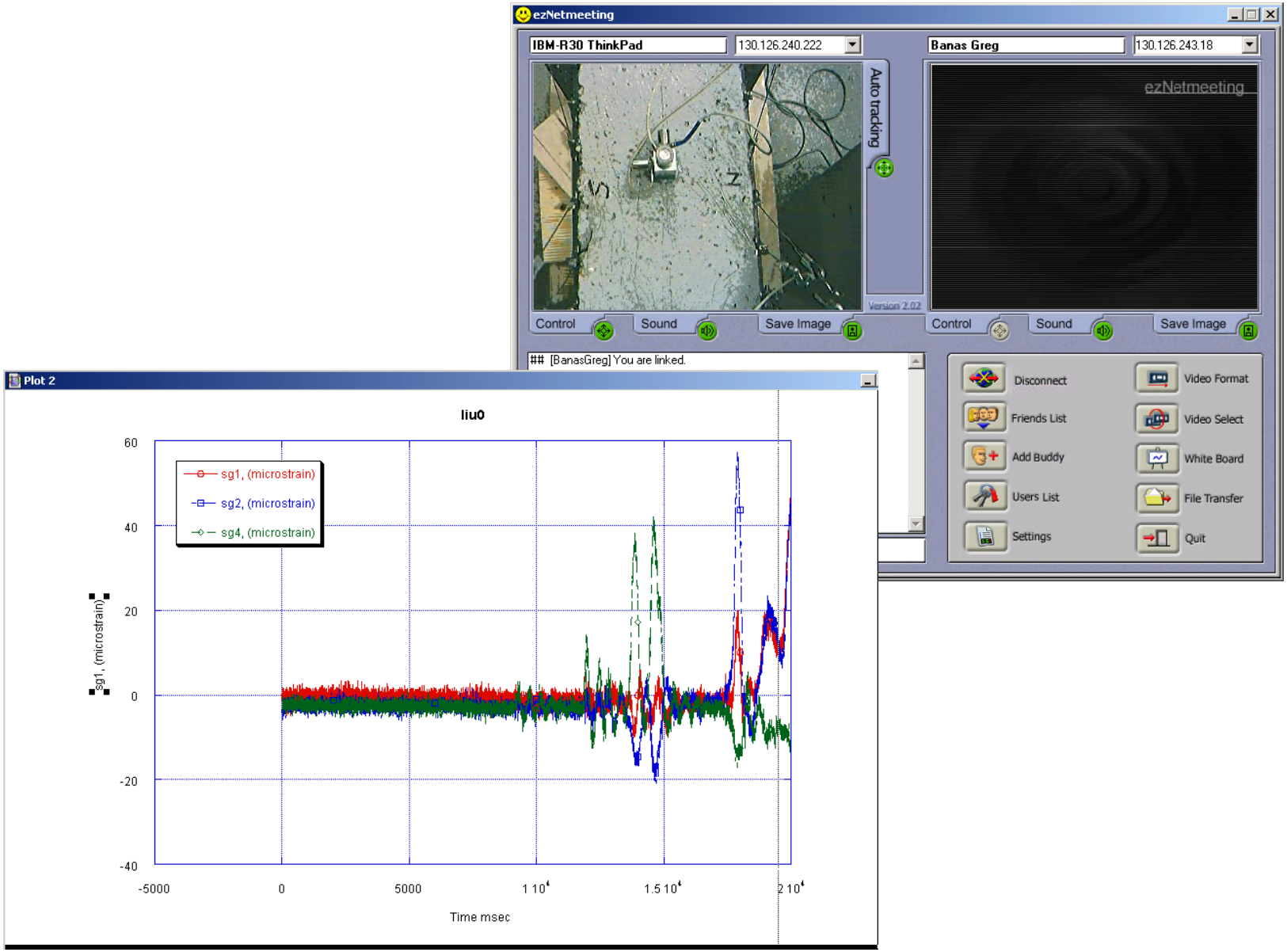
Tilt Sensors

Pressure sensors






GP contlogxyyxyy1
File Edit Operate Tools Browse Window Help
This program will perform continuous data logging, display and storage of up to eight channels from your test. One data file is produced containing data points spaced at your chosen interval, and two X-Y-Y plots of the data are provided as the data is taken. Once you're ready to start, click on the run arrow above.
Once you start this program, the digital readouts below show how much signal voltage is produced by each channel. These are provided to assist you in determining what these voltages represent in terms of engineering units, zeroing or calibrating your sensors.
When ready to proceed, click the PROCEED button below.
Channel 0 (volts)
0.0412
Channel 1 (volts)
0.0521
Channel 2 (volts)
0.0506
Channel 3 (volts)
0.0528
Channel 4 (volts)
0.1361
Channel 5 (volts)
0.1328
Channel 6 (volts)
0.0194
Channel 7 (volts)
-0.1978
Slot Number
1
Plot 1
liu0
acce-w, (g)
accn-s, (g)
accvert, (g)
acce-w, (g)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-5000
0
5000
1 10^4
1.5 10^4
2 10^4
Time msec


ezNetmeeting
IBM-R30 ThinkPad
130.126.240.222
Banas Greg
130.126.243.18
Auto tracking
ezNetmeeting
Version 2.02
Control
Sound
Save Image
Control
Sound
Save Image
[BanasGreg] You are linked.
Disconnect
Friends List
Add Buddy
Users List
Settings
Video Format
Video Select
White Board
File Transfer
Quit
Plot 2
liu0
sg1, (microstrain)
sg2, (microstrain)
sg4, (microstrain)
60
40
20
0
-20
-40
sg1, (microstrain)
-5000
0
5000
1 10⁴
1.5 10⁴
2 10⁴
Time msec

Facility Life-Cycle Information Integration

Design/Engineering

Construction

Operation/ Maintenance/ Disposal

Sensor Design

Sensor Installation

Real-time monitoring

Ubiquitous Computing & Information Integration

Conclusions

- Main Challenges of Facility Operation & Maintenance
  - Conditions & Record Tracking
  - Resource Management
- New Information Technology Advances
  - Mobile Computing, Wireless Communications, Sensors
- Life-cycle Information Integration